Chapter 3
PLANNING AREA DESCRIPTION

INTRODUCTION AND OVERVIEW

The Lower East Coast (LEC) Planning Area covers approximately 1,200 square miles and includes essentially all of Miami-Dade, Broward, and Palm Beach counties, most of Monroe County, and the eastern portion of Hendry and Collier Counties (**Figure 1**). The entire Lake Okeechobee Service, which includes part of four additional counties, Martin, Okeechobee, Glades and Lee, was incorporated into the analyses because of their reliance on the Lake Okeechobee for a portion of their water supply. This area encompasses a sprawling, fast-growing urban complex that, according to the 1990 census, provided homes for 6.3 million people, primarily along the coast. The planning area has extensive, economically significant agricultural lands and world renowned environmental resources such as the Everglades ecosystem and Lake Okeechobee, the largest freshwater lake in the southern United States. Highly productive coastal estuaries such as Biscayne Bay and Florida Bay occur along the shores.

Natural Features

The LEC Planning Area has many significant and unique natural resources and features that make this area especially worthy of protection, as well as desirable for human use and settlement. The region has a very suitable climate with mild temperatures and ample amounts of rainfall. The topography is low and flat, with numerous, extensive wetlands, and significant lakes and rivers. Many areas are covered with rich organic soils that support lush natural plant communities and highly productive farms. Undeveloped areas of the region support a broad diversity of native subtropical plant and animal communities, including many threatened and endangered species.

Historically, the watershed of the LEC Planning Area began in Central Florida, south of Orlando. Water from lakes and wetlands in that region overflowed natural drainage divides during wet periods and moved slowly southward, through Lake Kissimmee and into the Kissimmee River. The Kissimmee River, in turn, then meandered slowly southward for about 90 miles to flow into Lake Okeechobee. Lake Okeechobee was much larger than it is today and was bordered by extensive freshwater marshes and forests, especially along its southern border. When water levels in the lake were high, water flowed south into the extensive wetlands of the Everglades, moving slowly southward through this “River of Grass” to Florida Bay and the Ten Thousand Islands.

The quality of water that historically existed in South Florida is unknown, but analyses of remaining areas that relatively undisturbed, suggest that natural surface water was extremely pure, containing very low levels of dissolved solids and nutrients.

Man-Made Features

The Kissimmee River was channelized and degraded, beginning in the late 1800s and culminating with completion of the Kissimmee River Project in the 1970s. Lake Okeechobee is especially important to the LEC Planning Area because it forms the headwaters of the planning area. The lake has been diked around its borders and structures and gates have been constructed to regulate the flow of water to and from the lake. Today, Lake Okeechobee provides a multifunctional reservoir from which the South Florida Water Management District (District, SFWMD) has the ability to move water to the Everglades, to coastal communities, to agricultural interests in the Everglades Agricultural Area (EAA), and to the St. Lucie Canal and Caloosahatchee River basins. Much of the historic Everglades has been developed for urban and agricultural use. These regional wetlands are crossed by large canals that are designed to provide drainage and convey water to coastal communities and tide water. Protective levees were constructed around the remaining northern Everglades to create multipurpose WCAs (WCAs). Everglades National Park was created at the southern end to protect and restore natural plant and animal communities

South Florida today is characterized by highly productive agricultural regions and rapidly growing urban areas that lie directly adjacent to extensive aquatic and wetland ecosystems. Many of these natural systems are threatened as a result of water management activities that were designed to support agricultural and urban development. Urban landscapes occupy most of the higher elevation areas. Extensive agricultural areas cover much of the interior of the peninsula north and south of Lake Okeechobee and along the interior margins of the coastal urban areas. Both urban and agricultural land uses require increasing levels of water supply and flood control and produce degraded runoff that needs to be treated or stored prior to release back into natural systems.

Resource Concerns

The Kissimmee River is currently undergoing ecological restoration. Diking and management of water levels in Lake Okeechobee have reduced the surface area of the lake and eliminated most of the surrounding littoral wetlands. The lake now requires frequent regulatory water releases to avoid flooding and to maintain lowered water levels. Large regulatory releases can severely damage the St. Lucie and Caloosahatchee estuaries. The Everglades have been reduced in area by half due to agricultural and urban expansion. The remaining Everglades ecosystem is declining largely as a result of altered water regimes, drainage, compartmentalization, and degraded water quality. This degradation is evidenced by vegetation change, decreasing wildlife populations, and loss of organic soils. At the downstream end, the Florida Bay ecosystem experiences altered salinities due to decreased freshwater heads and inflows from the Everglades. The altered salinities have impacted habitats, nursery grounds, plants, and animals.

The environmental problems in South Florida today can be attributed largely to a diminished capacity to retain the huge volumes of water that once pooled and sheetflowed across the predrainage landscape. Loss of this capacity to store fresh water on the surface and under ground has led to a decline in ground water levels. This has caused inland migration of salt water in coastal aquifers. Today, surface water that comprised an essential feature of South Florida ecosystems is considered a threat to coastal development and is either discharged through canal systems to tide or is stored at unnaturally high levels in remnant diked wetlands of the Everglades. Many of these problems are recognized to be unanticipated effects of the existing Central and Southern Project for Flood Control and Other Purposes (C&SF Project). They are exacerbated by the continually increasing population in South Florida. The result is a currently nonsustainable system of urban, agricultural, and natural systems that exceeds the capacity, or is hampered by, existing water management facilities.

The following discussion is a brief summary of existing physical, ecological, and socioeconomic conditions within the study area. It does not attempt to provide comprehensive coverage of all resources or concerns. Instead, it summarizes baseline resources that are present in the study area and may be affected by implementation of this water supply plan.

TOPOGRAPHY

The surface features of central and southern Florida are largely of marine or coastal origin with subsequent erosion and modification by nonmarine waters. The features include flat, gently sloping plains; shallow water-filled depressions; elevated sand ridges; and a limestone archipelago. The elevations of the ridges and plains are related to former higher stands of sea level. Some ridges were formed above the level of these higher seas as beach ridges while the plains developed as submarine shallow sea bottoms.

The topography of the District has low elevation and wide areas of very low relief. Nearly all of the District is less than 200 feet above sea level and nearly half its area is less than 25 feet above sea level. Elevations within the District generally decline from north to south.

The bottom of Lake Okeechobee is approximately at sea level. Water levels in the lake generally range from 11 to 18 ft NGVD The land immediately surrounding Lake Okeechobee is at an elevation of about 20 to 25 ft NGVD. The coastal regions and most of the peninsula south of the latitude of Lake Okeechobee lie below 25 ft NGVD in elevation. From Lake Okeechobee southward an axial basin, occupied by the lake and the Everglades, occurs near the longitudinal center of the peninsula with slightly higher ground to the east and west. A small area near Immokalee and parts of the Atlantic Coastal Ridge are higher than 25 ft NGVD. Except for the coastal and beach ridges, this southern region is very flat in appearance and slopes vary gradually from approximately 25 ft NGVD. in the vicinity of Lake Okeechobee to sea level at the coasts.

Land elevations in the WCAs generally range from about 16 ft NGVD at the northern end of WCA-1 to about 9 to 10 ft NGVD at the southern end of WCA-3. Within Everglades National Park, the land surface generally slopes from 8 to 9 ft NGVD at the northern end to below sea level as the freshwater wetlands of the Everglades merge with the saltwater wetlands of Florida Bay.

Because changes in elevation are very gradual, and because much of South Florida is difficult to access, detailed topographic data are not available for much of the region, especially within the remaining Everglades. Accurate topographic information is an essential requirement for both surface and ground water modeling efforts.

GEOLOGY AND SOILS

The geology and soils of South Florida represent many of the opportunities, constraints, and impacts of regional water management. The high transmissivity of the Biscayne aquifer allows rapid recharge of LEC Planning Area wellfields, increases the tendency for flooding to occur in low-lying lands east of the Everglades, and has set the stage for the issue of seepage control. Loss of peat soils of the Everglades, as a result of drainage, has reduced the capacity of the system to retain water and is an indicator of ecosystem change.

Lake Okeechobee and much of the Everglades are underlain by peat and muck soils that developed in a shallow basin with poor natural drainage under prolonged conditions of flooding. Beneath these surface layers of organic material lies the Fort Thompson formation of interbedded sand, shell, and limestone. Bedrock in the Everglades is almost entirely limestone.

The Atlantic Coastal Ridge along the lower east coast is mostly underlain by thin sand and Miami Limestone that are highly permeable and moderately-to-well drained. West of the coastal ridge, soils contain fine sand and loamy material and have poor natural drainage. Rockland areas on the coastal ridge in Miami-Dade County are characterized by weathered limestone surfaces and karst features such as solution holes and sinkholes. Higher elevation marshes of the southern Everglades on either side of Shark River Slough are characterized by calcitic marl soils deposited by algal mats and exposed limerock surfaces with karst features. A generalized soils map of the region is shown in **Figure 10**.

Florida Bay is underlain by Miami Limestone with variable sediment cover of sand, exposed bedrock, and mudbanks. The Ten Thousand Islands consist of sandy barrier islands underlain primarily by the Tamiami formation. Because of the low relief, numerous marshy back bays or lagoons, such as Whitewater Bay, occupy exposed limestone surfaces behind the slightly higher buildup of sand on beaches along the Gulf of Mexico. The Florida Keys are made up of highly permeable Key Largo Limestone in the upper Keys and less permeable Miami Oolite on the lower Keys.

South Florida contains three major carbonate aquifer systems. These systems are the Surficial Aquifer System, the Intermediate Aquifer System, and the Floridan Aquifer System.

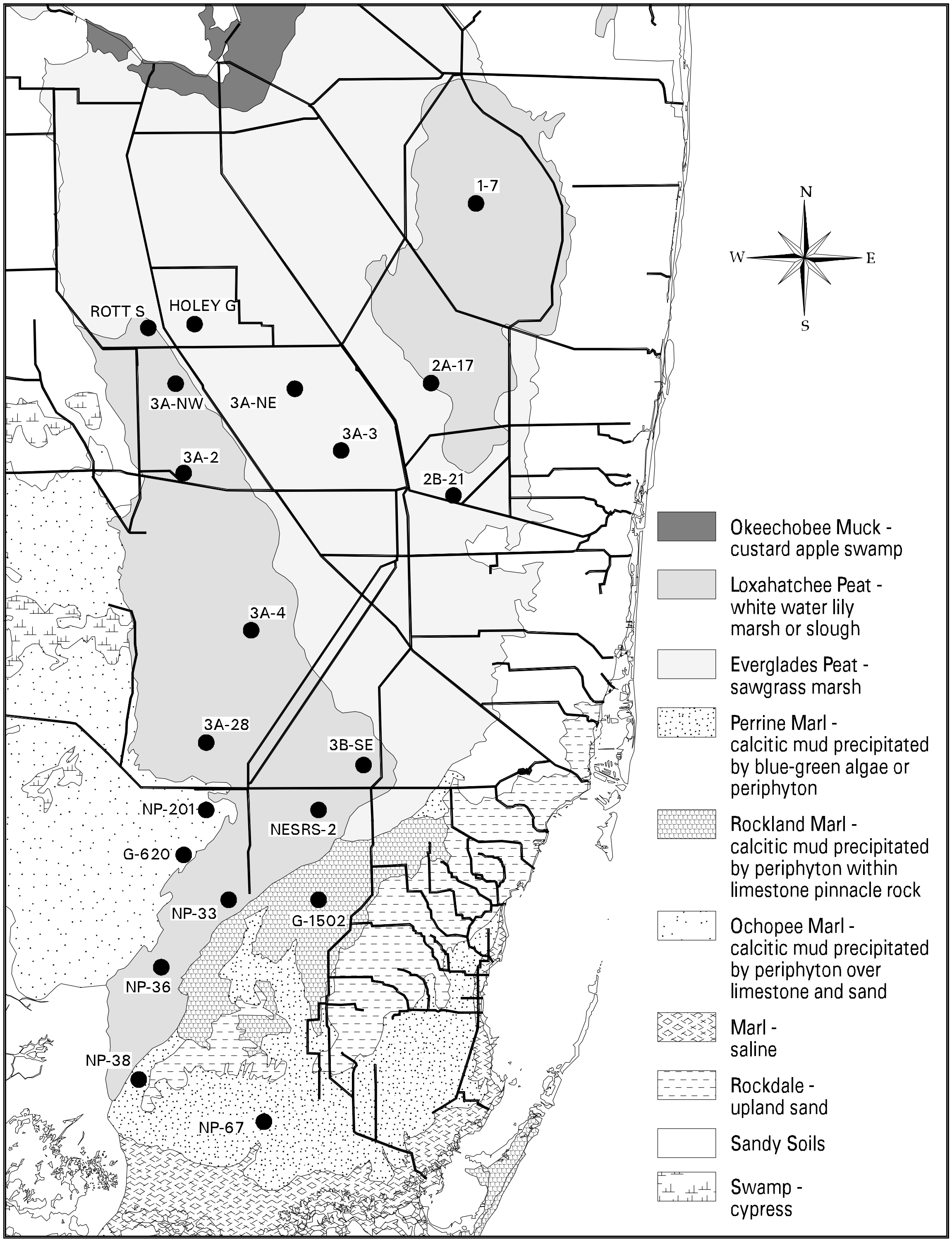

Figure 10. Generalized Soils Map of Lower East Coast Planning Area.

The Surficial Aquifer System is comprised of rocks and sediments from the land surface to the top of an intermediate confining unit. The discontinuous and locally productive water bearing units of the Surficial Aquifer System include the Biscayne aquifer, the undifferentiated surficial aquifer, the coastal aquifer of Palm Beach and Martin counties, and the shallow aquifer of southwest Florida. Practically all municipal and irrigation water is obtained from the Surficial Aquifer System.

The Intermediate Aquifer System consists of beds of sand, sandy limestone, limestone, and dolostone that dip and thicken to the south and southwest. In much of South Florida, the Intermediate Aquifer System represents a confining unit that separates the Surficial Aquifer System from the Floridan Aquifer System.

The Floridan Aquifer System is divided by a middle confining unit into the upper and lower Floridan aquifers. In the LEC Planning Area, from Jupiter to south Miami, the upper Floridan aquifer is being considered for storage of potable water in an Aquifer Storage and Recovery (ASR) Program. In the lower Floridan aquifer there are zones of cavernous limestones and dolostones with high transmissivities. However, because these zones contain saline water, they are primarily for injection of treated effluent wastewater.

CLIMATE

The subtropical climate of South Florida, with distinct wet and dry seasons, high rates of evapotranspiration, and climatic extremes of floods, droughts, and hurricanes represents a major physical driving force that sustains the Everglades while creating water supply and flood control issues in the agricultural and urban segments. South Florida's climate, in combination with low topographic relief, delayed the development of South Florida until the Twentieth Century, provided the main motivation for the creation of the C&SF Project 50 years ago, and continues to drive the water management planning of the Comprehensive Everglades Restoration Plan (CERP) and the *Lower East Coast Regional Water Supply Plan* today.

Seasonal rainfall patterns in South Florida resemble the wet and dry season patterns of the humid tropics more than the winter and summer patterns of temperate latitudes. Of the 53 inches of rain (average) that South Florida receives annually, 75 percent falls during the wet season months of May through October. During the wet season, thunderstorms that result from easterly trade winds and land-sea convection patterns occur almost daily. Wet season rainfall follows a bimodal pattern with peaks during May-June and September-October. The amount of rainfall varies regionally within the District (**Figure 11**).

Tropical storms and hurricanes also provide major contributions to wet season rainfall with a high level of interannual variability and low level of predictability. During the dry season, rainfall is governed by large-scale winter weather fronts that pass through the region approximately weekly. High evapotranspiration rates in South Florida roughly equal annual precipitation. Recorded annual rainfall in South Florida has varied from 37 to 106 inches, and interannual extremes in rainfall result in frequent years of flood and

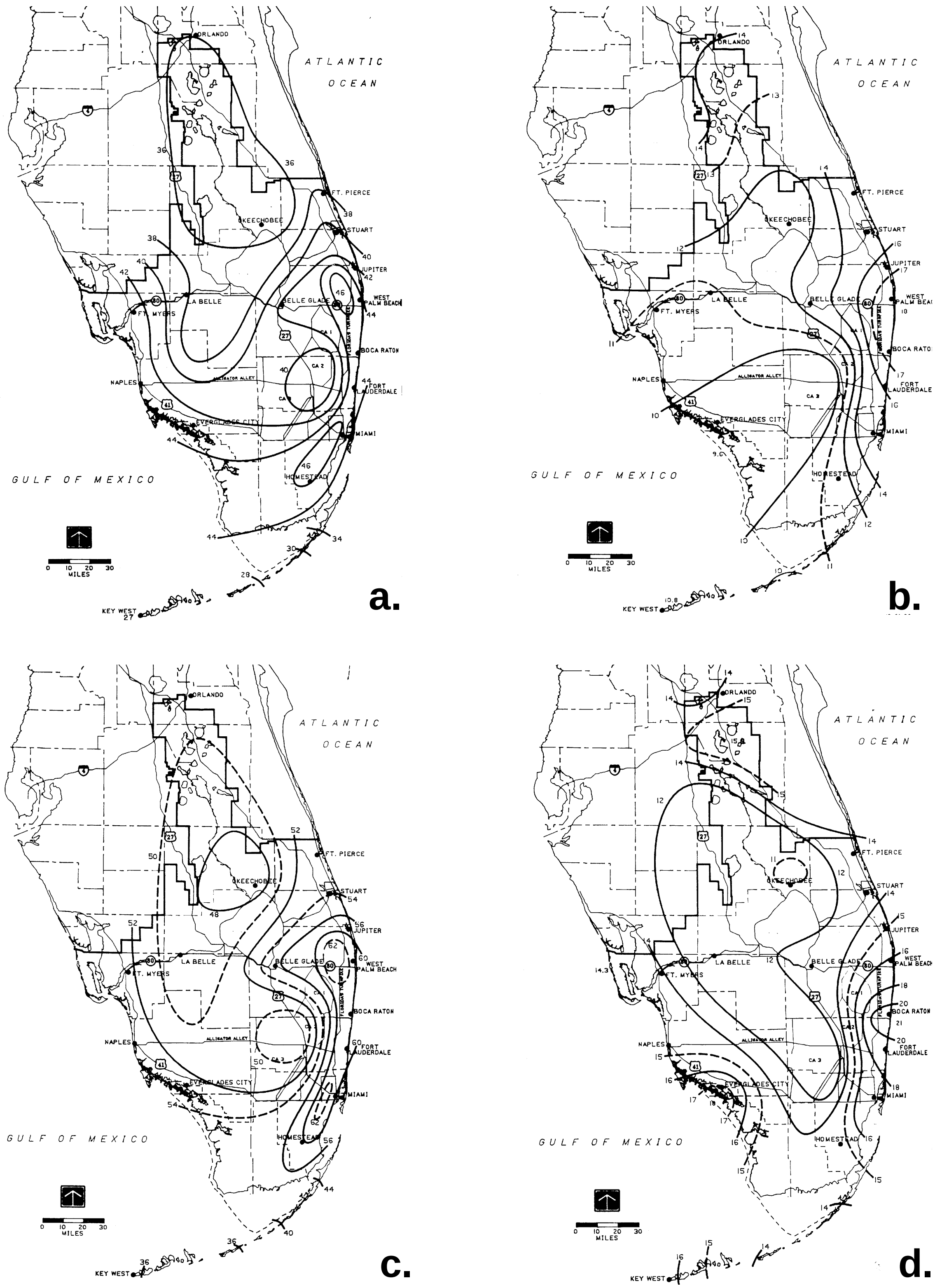

Figure 11. Rainfall Patterns in South Florida, Indicating **a.** Average Wet Season, **b.** Dry Season, **c.** Annual Rainfall Amounts (inches), and **d.** Expected Rainfall During an Extreme (Three-Day Rainfall for 100-Year Return Period.

drought. Multiyear high and low rainfall periods often alternate on a timescale approximately on the order of decades.

NATURAL SYSTEMS

Vegetation

The location of South Florida between temperate and subtropical latitudes, the proximity to the West Indies, the expansive wetland system of the greater Everglades, and the low levels of nutrient inputs under which the Everglades evolved all combine to create a unique and species-rich flora and vegetation mosaic. Today nearly all aspects of South Florida's native vegetation have been altered or eliminated by the development, altered hydrology, nutrient inputs, and spread of exotics that have resulted directly or indirectly from a century of water management. **Figure 12** indicates the nature and extent of changes in natural systems during the past 100 years.

Riparian plant communities of the Kissimmee River and its floodplain are recovering from channelization and drainage. The macrophyte communities of the diminished littoral zone of Lake Okeechobee are now contained within the Hoover Dike. They remain essential for the ecological health of the lake but are stressed by extreme high and low lake levels and by the spread of exotics.

Below the lake, all of the pond apple swamp forest and most of the sawgrass plain of the northern Everglades have been converted to the EAA. Also, eliminated is the band of cypress forest along the eastern fringe of the Everglades that was largely converted to agriculture after the eastern levee of the WCAs cut off this community from the remaining Everglades. The mosaic of macrophytes and tree islands within the WCAs and Everglades National Park is altered by changes in hydrology, exotic plant invasion, and nutrient inputs.

The problems of the Everglades extend to the mangrove estuary and coastal basins of Florida Bay, where the forest mosaics and submerged aquatic vegetation show the effects of diminished freshwater heads and flows upstream that are exacerbated by sea level rise. The upland pine and hardwood hammock communities of the Atlantic coastal ridge are interspersed with wet prairies and cypress domes and dissected by "finger glades" watercourses that flowed from the Everglades to the coast. These remain only in small and isolated patches that have been protected from urban development.

More detailed documentation of existing vegetation focuses on wetland systems that have been most seriously degraded and that will receive the most benefits from the implementation of the C&SF Project Comprehensive Review Study (Restudy) components. Those systems include the Everglades peatland, the Everglades marl prairie and rocky glades, and the mangrove estuaries and coastal basins of Florida Bay. Other natural systems in South Florida already have restoration plans and have lesser impacts from man. These systems include the Kissimmee River, where restoration is already in progress; Lake Okeechobee for which a revised regulation schedule is planned to protect

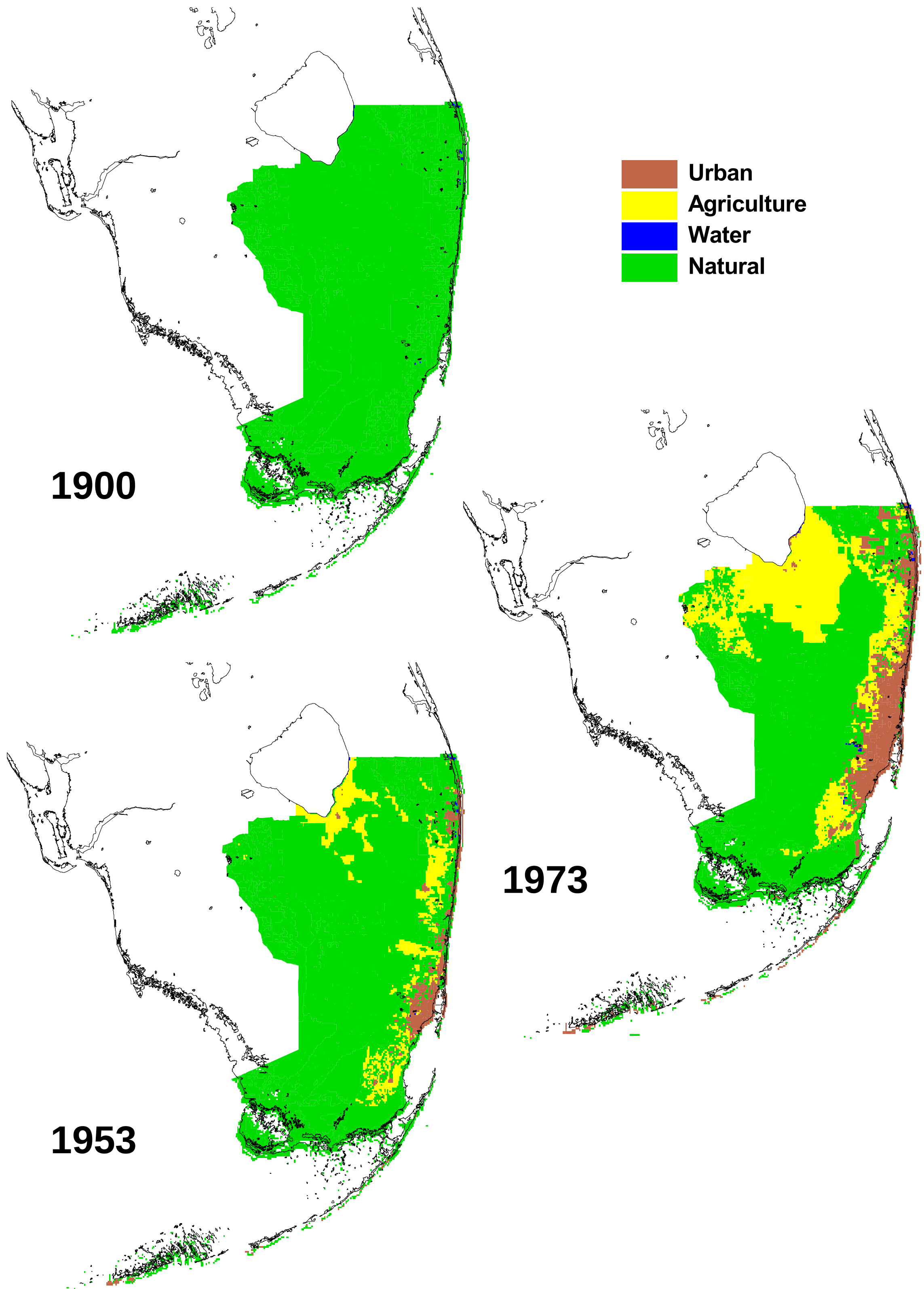

Figure 12. Changes in Natural Systems in the Lower East Coast Planning Area, 1900 to 1973.

littoral macrophyte communities; and the Big Cypress National Preserve where vegetation impacts and fixes are relatively minor compared to the Everglades. The Atlantic coastal ridge pinelands and hardwood hammocks are unique subtropical ecosystems that have very little protection and are rapidly disappearing.

Fish And Wildlife

The life cycles, community structures, and population densities of the fauna of South Florida are intricately linked to regional hydrology. The current status of fish and wildlife has been strongly influenced by the cumulative effects of drainage activities early this century, the C&SF Project, and the ensuing agricultural and urban development. The major emphasis in this section is on those faunal groups that appear to have declined as a result of hydrologic changes caused by the C&SF Project. The major linkages between hydrologic alterations and fauna that are emphasized here include the decline of aquatic food webs and populations, higher level consumers that depend upon them, shifts in habitats to those less favorable to faunal communities, and the reduction in the spatial extent of the Everglades wetland system.

A critical link in the aquatic food webs, and one that appears to have been impacted by hydrologic alterations, is the intermediate trophic level of the small aquatic fauna. The small marsh fishes, macroinvertebrates, amphibians, and reptiles that form the link between the algal and detrital food web bases of the Everglades and the larger fishes, alligators, and wading birds that feed upon them are currently diminished due to loss of habitat and changes in hydrology.

Included in the freshwater aquatic community of South Florida are the larger sport species such as the largemouth bass (*Micropterus salmoides*), sunfishes, and black crappie (*Lepomis nigromaculatus*). Lake Okeechobee is renowned for the trophy bass from its littoral zone and for an abundant black crappie fishery. Largemouth bass also naturally inhabit the deep water sloughs and wet prairies of the Everglades, where they grow at a rate of one pound per year of uninterrupted flooding.

Shortened hydroperiods in much of the LEC Planning Area presently confine larger bass mostly to canals, which provide a popular recreational fishery. Unfortunately, Everglades bass contain high body burdens of mercury, which make them unsuitable for frequent human consumption. Prolongation of hydroperiods that will be provided by an increase in water supply to the Everglades, should revitalize and expand the fishery for the largemouth bass to the sloughs and wet prairie and create new fisheries in reservoirs. Bass fisheries in remaining canals should also be substantially improved.

The American alligator (*Alligator mississipiensis*) is a keystone species in the Everglades. Holes that are created by alligators form ponds where aquatic fauna survive droughts. Mounds of sediment that are excavated from the holes create higher-elevation habitat for willow and other swamp forest trees. In addition to modifying topography, the American alligator is the top predator in the Everglades and feeds on every level of the food chain, from small fishes to wading birds, at various stages in its life.

The most conspicuous indicators of ecosystem health in the Everglades are the plummeting populations of wading birds. At present, nesting birds have declined to only ten percent of their historical number and they continue to decline. The food bases for these species are mostly contained in the freshwater marsh fish assemblage of the Everglades and the low salinity mangrove fish assemblage of the estuarine transition zone.

Due to diminished freshwater heads and flows upstream, habitats for the American crocodile (*Crocodylus acutus*), migratory waterfowl, and nursery grounds of sport fishes and pink shrimp (*Penaeus duorarum*) were also degraded.

The deer population has benefited from lower water levels. More white-tailed deer (*Odocoileus verginianus*) presently live in the Everglades than occurred under predrainage conditions. However, during high water periods, large-scale mortality can occur when the deer are stranded on overbrowsed tree islands.

Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS), has identified 18 federally-listed plant and animal species that would likely be affected by changes in water management practices (**Table 3**). Of the listed species, critical habitat has been designated for the West Indian manatee (*Trichechus manatus*), the snail kite (*Rostrhamus sociabilis plumbeus*), the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), and the American crocodile. For a description of these critical habitat geographic designations and a complete species description, taxonomy, distribution, habitat requirements, management objectives, and current recovery status, see the USFWS web site (http://www.fws.gov). A complete listing of all the federally-listed threatened and endangered plant and animal species occurring or thought to occur within the study area is also available from this web site. The Florida Fish and Wildlife Conservation Commission (FFWCC) provides information on state-listed species (**Table 3**).

WATER QUALITY

Generally, water quality conditions in South Florida are assess on a biannual basis by Florida Department of Environmental Protection (FDEP). The *Florida Water Quality Assessment 1998 305 (b) Report* (Paulic and Hand, 1998) provides an overall view of water quality in South Florida, including much of the LEC Planning Area.

Pollutants of Concern

Water quality conditions in the study area are significantly influenced by development related activities. Hydrologic alterations have led to significant changes in the landscape by opening large land tracts for urban development and agricultural practices, and by the construction of extensive drainage networks. Natural drainage patterns in the region have been disrupted by the extensive array of levees and canals such that nonpoint source (storm water) runoff and point sources of pollution (wastewater discharges) are now part of the normal hydrological regime in many areas. Several

Table 3. Threatened and Endangered Plant and Animal Species Likely to be Affected by the Lower East Coast Regional Water Supply Plan.[a]

Scientific Name	Common Name	USFWS	FWCC
Trichechus manatus	West Indian Manatee	E[b]	E[b]
Felis concolor	Florida panther	E	E
Rostrhamus sociabilis plumbeus	snail kite	E[b]	E
Mycteria americana	wood stork	E	E
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	E[b]	E
Crocodylus acutus	American crocodile	E[b]	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E	E
Picoides borealis	red-cockaded woodpecker	E	T
Haliaeetus leucocephalus	bald eagle	T	T
Polyborus plancus	Audubon's crested caracara	T	T
Drymarchon corais couperi	Eastern indigo snake	T	T
Aphelocoma coerulescens	Florida scrub jay	T	T
Cucurbita okeechobeensis	Okeechobee gourd	E	
Amorpha crenulata	crenulate lead plant	E	
Euphorbia deltoidea	deltoid spurge	E	
Galactia smallii	Small's milkpea	E	
Polygala smallii	tiny polygala	E	
Euphorbia garberi	Garber's spurg	T	

a. E = Endangered; T = Threatened
b. Designated Critical Habitat

pollutants of concern in the study area have been identified, including nutrients, pesticides, mercury, other metals, biologicals (fecal coliforms and pathogens), physical parameters, and other constituents. Of this list, phosphorus, pesticides, and mercury are considered to be the most important water quality pollutants of the region and are discussed below.

Phosphorus

Historically, South Florida waters were low in nutrients (oligotrophic). Due to human activities including the ditching and draining of wetlands and the expansion of agricultural practices, water bodies from the Kissimmee River southward have become nutrient enriched to various degrees. The most important of these nutrients, based on its effects on the health of South Florida ecosystems, is phosphorus. Farming areas surrounding Lake Okeechobee in general have contributed to elevated phosphorus levels in the Kissimmee River, Lake Okeechobee, Caloosahatchee River, and the Everglades. Urban storm water runoff is another source of phosphorus to the Everglades and South Florida coastal systems. In general, the trend for phosphorus concentrations is a decrease from north (Kissimmee River and EAA) to south (Everglades National Park). Nutrient removal occurs naturally in lakes and wetlands, due to the water quality treatment provided by plants and bacterial processes. Elevated nutrient levels occur when loading rates exceed the natural removal capacity. The resulting increased concentration of nutrients is termed eutrophication and may have various ecological impacts that include increased primary productivity, loss of water column dissolved oxygen, algal blooms, and changes in vegetation and biodiversity. Such effects of phosphorus loadings may ultimately reduce or destroy a water body's habitat and/or recreational value.

Pesticides

Many types of pesticides are applied to or persist in South Florida waters, sediments and soils. The South Florida region is unique in that large and sensitive ecosystems exist in the midst of urban and intensive agricultural areas. Major amounts of pesticides are used in ground and/or aerial applications related to agricultural production, mosquito control, aquatic plant growth in local waterways, and golf course, homeowner lawn, and vegetation maintenance. Pesticides used in these ways threaten sensitive ecosystems and humans due to the intense year-round use, coupled with the shallow water tables and large-scale consumption of ground and surface waters.

Mercury

Mercury is a toxic heavy metal. Levels of mercury in water, animal tissue, sediments, periphyton, air, and soil are elevated in certain areas of South Florida. However, the sources, distribution, magnitude, transport, transformations, and pathways of mercury through the Everglades ecosystem are poorly understood. Among the possible mercury sources in South Florida are natural mineral and peat deposits and atmospheric deposition from global, regional, and local sources. Local sources include generating plants and waste incinerators. Mercury is now believed to primarily come from atmospheric deposition. Once elemental mercury is methylated by microbial action, it becomes biologically available in the food chain and its concentrations move up the food chain to top carnivores such as the Florida panther.

Surface Water Quality Conditions

Under Section 303(d) of the Federal Clean Water Act, states develop Total Maximum Daily Loads (TMDLs) for their water bodies that are not meeting designated standards. For the study area, FDEP listed over 118 priority water bodies/segments by basin:

- Lake Okeechobee (12)
- Caloosahatchee River Basin (11)
- Southeast Florida Basin (95)
- Florida Keys (0)

A map summarizing information available for the Southeast Basin and Lake Okeechobee is provided in **Figure 13**.

Lake Okeechobee is at the center of the South Florida drainage system, receiving flow from the Kissimmee River Basin, and to a lesser extent from EAA backpumping.

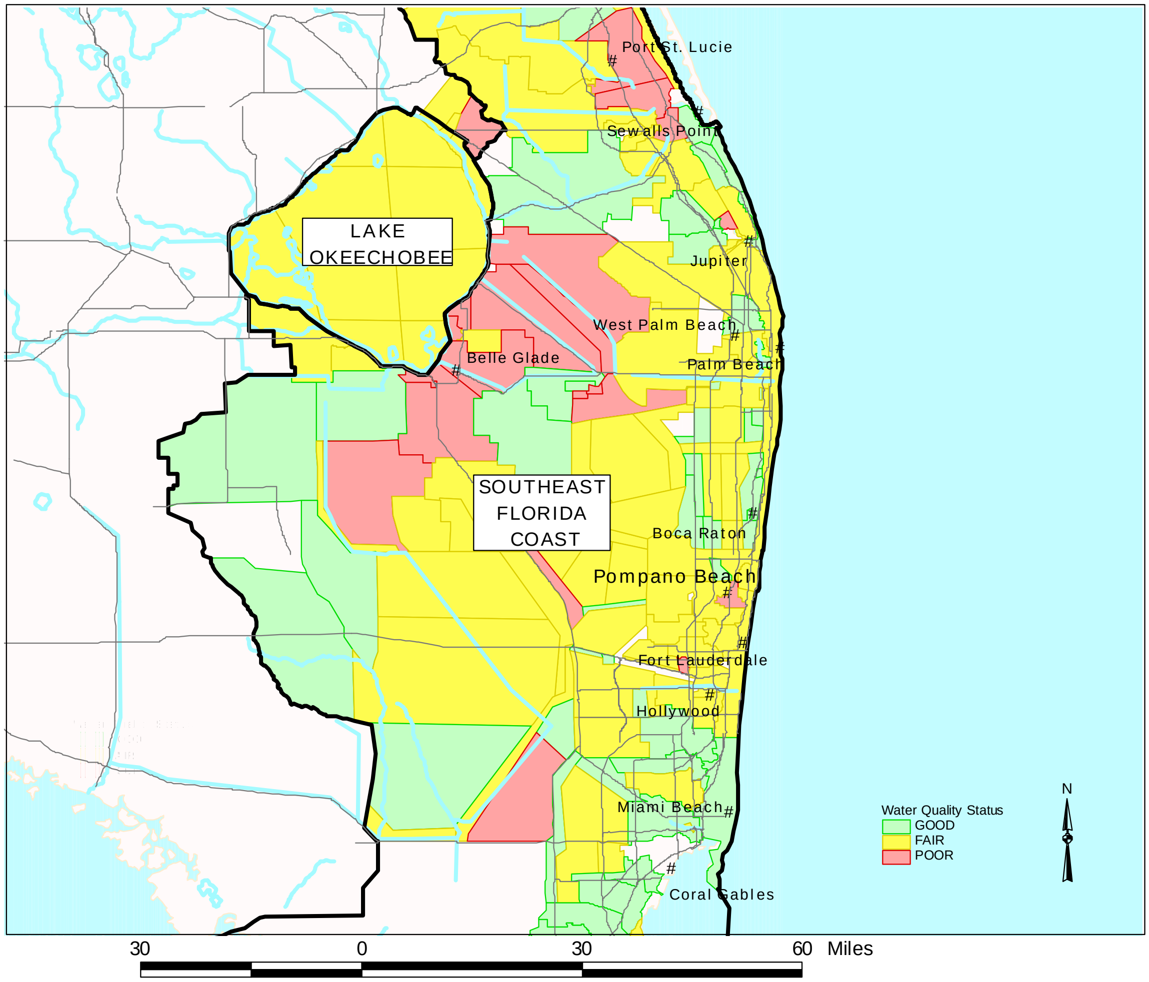

Figure 13. Results of FDEP Water Quality Assessment for Portions of the LEC Planning Region.

The lake may be considered an historically eutrophic water body that is becoming degraded, due primarily to nutrient inputs from the Kissimmee River and the Taylor Creek/Nubbin Slough basins. Despite extensive pollutant abatement programs implemented during the past 15 years, recent lake data indicate that nutrient concentrations and loads have shown no substantive improvement. Further, because the lake's phosphorus is internally recycled and large amounts of phosphorus are stored in watershed canal sediments, phosphorus levels in lake waters may not reach acceptable levels for many decades.

Water quality in the Caloosahatchee River is degraded in the upper and lower areas of the basin, due to agricultural and urban runoff, respectively. Problems associated with the degraded areas are typified by low dissolved oxygen levels, elevated conductivity, and decreased biodiversity. In urban sections of the basin, nonpoint storm water flows are associated with periodic algal blooms, fish kills, and low dissolved oxygen levels.

Extensive agricultural Best Management Practices (BMPs) have been applied in the EAA in the past several years to reduce the phosphorus load leaving the EAA. However, this area remains a primary source of pollutants for the WCAs. The highly altered hydroperiod, resulting from the levees and pump operations, may exacerbate water quality conditions in the WCAs, as evidenced by a general degradation of water quality in the areas along the canals and adjacent to pump stations. Construction of upstream Stormwater Treatment Areas (STAs) currently under way is expected to improve water quality conditions in the WCAs through time.

In the central Everglades, phosphorus concentrations entering the Everglades National Park were lower in 1997 than the interim and long-term limits established by the 1991 Settlement Agreement (USA v. SFWMD, 1991). No significant trends in annual average mercury concentrations in water, sediment, or fish have been observed for the past five years. The best water quality conditions in the Everglades National Park were found in central Shark River Slough and along the coastal regions of the basin.

Some parts of Florida Bay experienced massive seagrass and mangrove die-offs during the 1980s and 1990s that likely stem from a lack of circulation, high water temperatures, and increased levels of salinity. Water diverted into the lower east coast canals has reduced freshwater flows to the bay resulting in recorded salinities as high as 70 parts per thousand.

Water bodies in the LEC Planning Area are seriously degraded in the heavily urbanized areas, including the numerous man-made canals. For example, water quality in Lake Worth Lagoon is good near the inlets and poor in the area between the inlets. Canals and water bodies in and around Fort Lauderdale are degraded by urban runoff and historical wastewater discharges, and by agricultural runoff in western portions of the canals. The New River and Miami River canals are polluted by improperly functioning septic tanks, discharges from vessels, industrial activities, improper sewer connections, and storm water runoff. Problems associated with these pollutants vary, but may include high nutrient concentrations, high bacteria counts, dense growth of undesirable aquatic vegetation, low biological diversity, and occurrence of exotic plants and animals.

Water quality is good in open water areas of central and southern Biscayne Bay, and degraded in the area north of the Miami River Canal. High concentrations of heavy metals such as tin, copper, zinc, and chromium occur in sediments at marina sites.

Water quality conditions in the Florida Keys are generally good in areas open to the Atlantic or Gulf. However, many man-made canals and marinas have water quality problems that are exacerbated by stormwater runoff, seepage from septic tanks, and poor circulation.

Ground Water Conditions

The principal ground water resources for the LEC Planning Area are the Surficial Aquifer System, including the Biscayne aquifer, and the Floridan Aquifer System. Both are critical to the local ecology and economy. A cross-section of the geology of South Florida, depicting the aquifers, is shown in **Figure 14**.

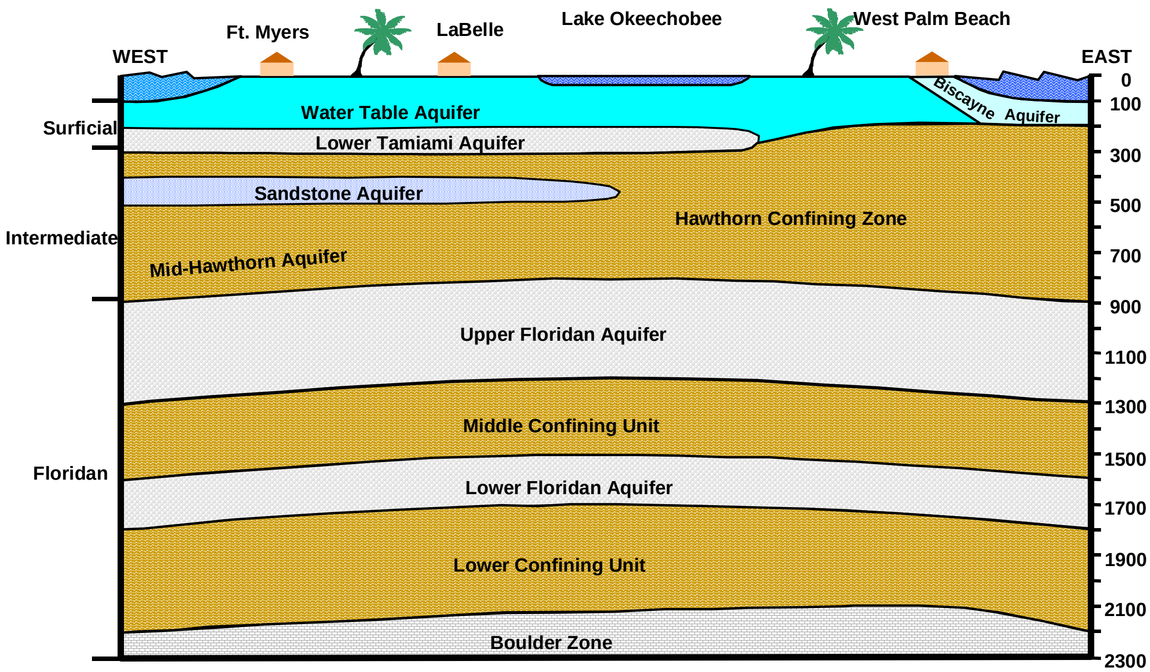

Figure 14. Geologic Cross-Section of South Florida Showing the Location of the Aquifers.

Surficial and Biscayne Aquifers

The Surficial and Biscayne aquifers provide most of the fresh water for public water supply and agriculture within the LEC Planning Area. Both are critical to the local ecology and economy. The Surficial Aquifer System is unconfined and extends throughout southeast Florida. A portion of the Surficial Aquifer System has distinctive geological characteristics, is highly productive, and has been designated as the Biscayne aquifer. Location, depth, and water levels in the Biscayne aquifer are shown in **Figure 15**. The Surficial Aquifer System provides major sources of water for the following uses:

- Meet drinking water requirements for more than four million people living in urban areas along Florida's lower east coast
- Maintain water levels in local wells, canals, and lakes
- Irrigate agricultural crops
- Replenish regional wetlands and provide base flow to estuaries such as Biscayne Bay and Florida Bay

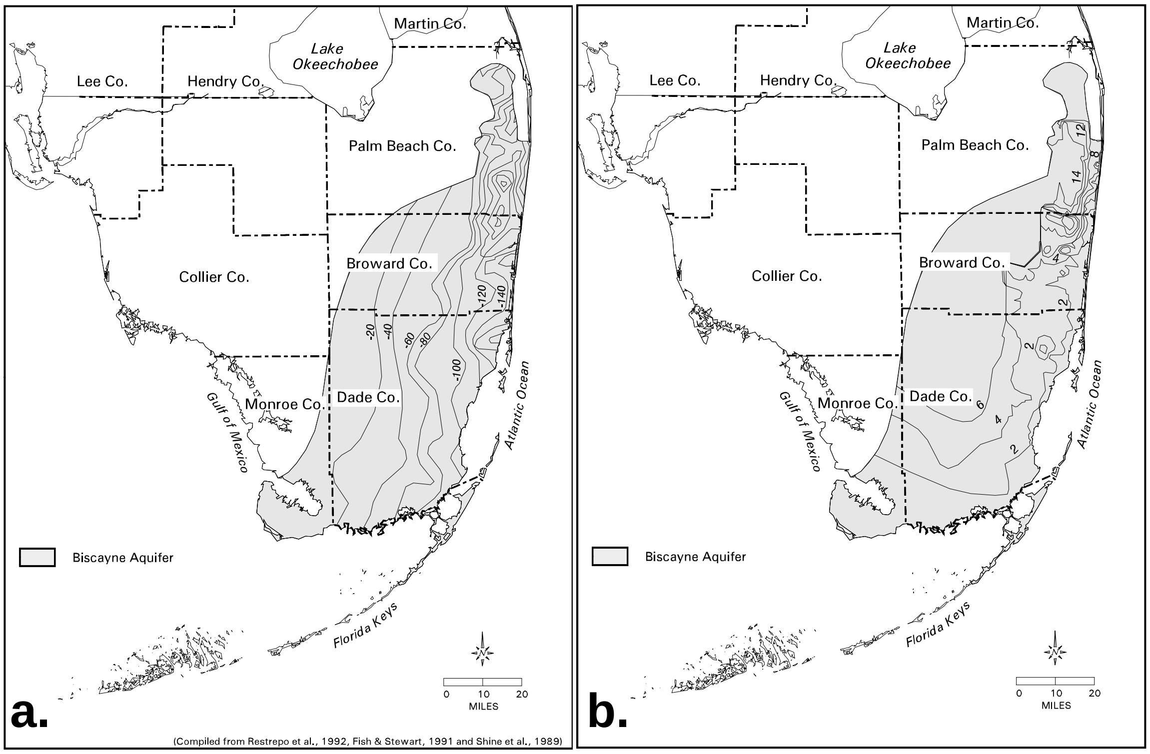

Figure 15. Location of the Biscayne Aquifer in Eastern Miami-Dade, Broward, and Palm Beach Counties with **a.** Average Aquifer Depth and **b.** Elevation of the Surface of the Aquifer.

The Biscayne aquifer is composed of units and formations principally deposited during the Pleistocene Epoch, or Great Ice Age. This interval of geologic time was a period of climatic instability where great glaciers would advance and retreat across the continents. As the glaciers advanced, sea level declined and large areas of South Florida became exposed as dry land. Deposition during this time occurred due to dune building and formation of freshwater limestones. As the glaciers melted, sea levels increased and eventually submerged the southern peninsula, creating a highly productive, shallow marine environment. During this time period, marine deposits dominated the composition of the Biscayne aquifer. Typical marine deposits from these high sea level stands occur throughout South Florida and include the coral limestones on Key Largo and the oolitic ridge along the coast (Hoffmeister, 1974).

The major geologic deposits that comprise the Biscayne aquifer include Miami Limestone, the Fort Thompson Formation, the Anastasia Formation, and the Key Largo Formation. The base of the Biscayne aquifer is generally the contact between the Fort Thompson Formation and the underlying Tamiami Formation of Plio-Miocene Age. However, in places where the upper unit of the Tamiami Formation contains highly permeable limestones and sandstones, the zones would also be considered part of the Biscayne aquifer if the thickness exceeds 10 feet (Fish and Stewart, 1991).

The Biscayne aquifer is composed of interbedded, unconsolidated sands and shell units with varying thickness of consolidated, highly solutioned limestones and sandstones

(Shine et al. 1989). In general, the Biscayne aquifer contains less amounts of sand and a greater percentage of solutioned limestone than the Surficial Aquifer System. The Biscayne aquifer is one of the most permeable aquifers in the world and has transmissivities in excess of seven million gallons per day, per foot of drawdown (Parker et al. 1955).

Due to the regional importance of the Biscayne aquifer, it has been designated as a sole source aquifer by the U.S. Environmental Protection Agency (USEPA) under the Safe Drinking Water Act and is, therefore, afforded stringent protection. This designation was made because it is a principal source of drinking water and is highly susceptible to contamination due to its high permeability and proximity to land surface in many locations. Major sources of contamination are saltwater intrusion and infiltration of contaminants from canal water. Sources of contamination include surface water runoff (pesticides and fertilizers); leachate from landfills, septic tanks, and sewage plant treatment ponds; and injection wells used to dispose of storm water runoff or industrial waste. Trichloroethylene (TCE) and vinyl chloride are examples of ground water contaminants of concern. Numerous hazardous waste sites (e.g., Superfund and Resource Conservation and Recovery Act sites) have been identified in the area underlain by the Biscayne aquifer. Action to remove existing contamination is under way at many of these sites. Waste management practices are generally monitored to prevent further contamination. The extent and depth to bottom of the Biscayne aquifer are shown in **Figure 15.**

Floridan Aquifer System

The Floridan aquifer system is a thick sequence of carbonate units. Less permeable carbonate units, referred to as the middle confining unit, separate the system into two major aquifers called the Upper and Lower Floridan aquifers. The Floridan Aquifer System is one of the most productive aquifers in the world and is a multiple-use aquifer system. Where it contains freshwater, it is the principal source of water supply, especially north of Lake Okeechobee. The Upper Floridan aquifer is used for drinking water supply in parts of Martin and St. Lucie counties.

From Jupiter to south Miami, water from the Floridan Aquifer System is mineralized (total dissolved solids are greater than 1,000 mg/L) along coastal areas and in southern Florida. More than 600 feet of low permeability sediments confine this aquifer and create artesian conditions. Although the head gradient is upward, the low permeability units prevent significant upward migration of saline waters into the shallower aquifers. Depth to the Floridan aquifer is approximately 900 feet in coastal Miami-Dade County. In the LEC Planning Area, the Upper Floridan aquifer is being considered for storage of potable water within an ASR Program. In the lower Floridan aquifer, there are cavernous zones with extremely high transmissivities. However, because these zones produce saline water, they are not used for drinking water supply. Because of their depth and salinity, these deeper zones of the Lower Floridan aquifer are used primarily for injection of treated effluent wastewater.

Saltwater Intrusion

The inland movement of saltwater is a major resource concern in the coastal areas of the LEC Planning Area and can significantly affect water availability in areas adjacent to saline water bodies. When water is withdrawn from the surficial aquifer at a rate, which exceeds its recharge capacity, the amount of freshwater head available to impede the migration of saltwater is reduced, and saltwater intrusion becomes likely. The saline interface moved significantly inland during the 1940s in southeast Broward County and northern Miami-Dade County due to construction of the coastal canals which drained the freshwater mound behind the coastal ridge. Historical changes in saltwater intrusion boundaries in Miami-Dade County are shown in **Figure 16**. More recently, several wells in the cities of Hollywood, Hallandale, and Dania have been taken out of service due to saltwater contamination. The recharge capacity of the aquifer was exceeded.

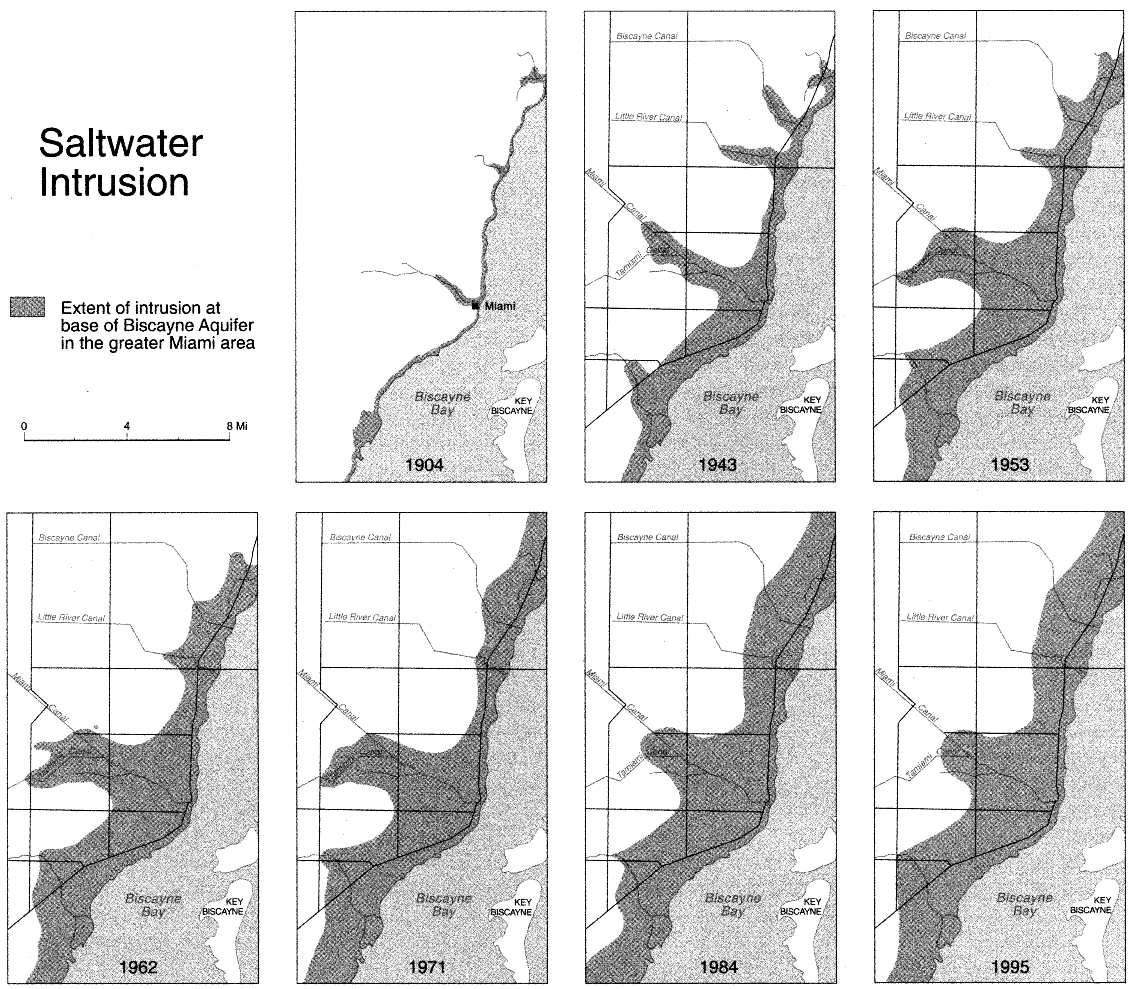

Figure 16. Historical Extent of Saltwater Intrusion in Coastal Miami-Dade County.

The District's Consumptive Use Permitting (CUP) criteria includes denial of permits that would cause significant saline water intrusion. Section 3.4, Saline Water Intrusion, of the District's Basis of Review for Water Use Permit Applications (BOR-1997) defines significant saline water intrusion as follows:

- Movement of saline water interface to a greater distance inland or vertically upward towards a freshwater source than has historically occurred as a consequence of seasonal fluctuations.
- A sustained increase from background values of saline monitor wells with regard to dissolved chloride concentration.

Impacts include the potential to permanently move the saline interface inland, reducing the quality and quantity of water available at existing wellfields and impeding future withdrawals at favorable locations (near population centers and treatment plants).

Historically, the District's CUP Program has required water users to maintain a minimum of one foot of freshwater head between their wellfields and saline water as a guideline for the prevention of saltwater intrusion. This guideline, in combination with a saltwater intrusion monitoring program, has been largely successful in preventing saltwater from occurring based on consideration of individual permits and utility operations The LEC Water Supply Plan is taking a more comprehensive view of the potential for saltwater by identifying areas that are most vulnerable and developing proactive measures to reduce occurrence of, and better manage, saltwater intrusion.

WATER MANAGEMENT

The LEC Planning Area portion of C&SF Project is divided into three hydrologically related geographical areas consisting of 1) Lake Okeechobee and the EAA; 2) the WCAs, and 3) the East Coast Canals.

Lake Okeechobee and Everglades Agricultural Area

Location and major features of the Lake Okeechobee Service Area (LOSA) and the EAA are shown in **Figure 17**. Water levels in Lake Okeechobee are regulated by a complex system of pumps and locks. A regulation schedule has been established for the Lake Okeechobee to achieve multiple use purposes and provide seasonal lake level fluctuations that vary from high stages in the late fall, winter, and early spring to low stages at the beginning of the wet season. The regulation schedules contain instructions and guidance on how project pumps, locks, and spillways are to be operated to maintain appropriate water levels. The schedule maintains a low lake stage to provide both storage capacity and flood protection for surrounding areas during the wet season. During the winter, lake levels may be increased to store water for the upcoming dry season. The general plan of operation is based on 1) flood protection from lake waters and hurricane driven wind tides for lands adjacent to the lake; 2) maintenance of an eight-foot navigation, as part of the Okeechobee Waterway; and 3) storage of water to meet requirements of agricultural and urban areas south and east of the lake.

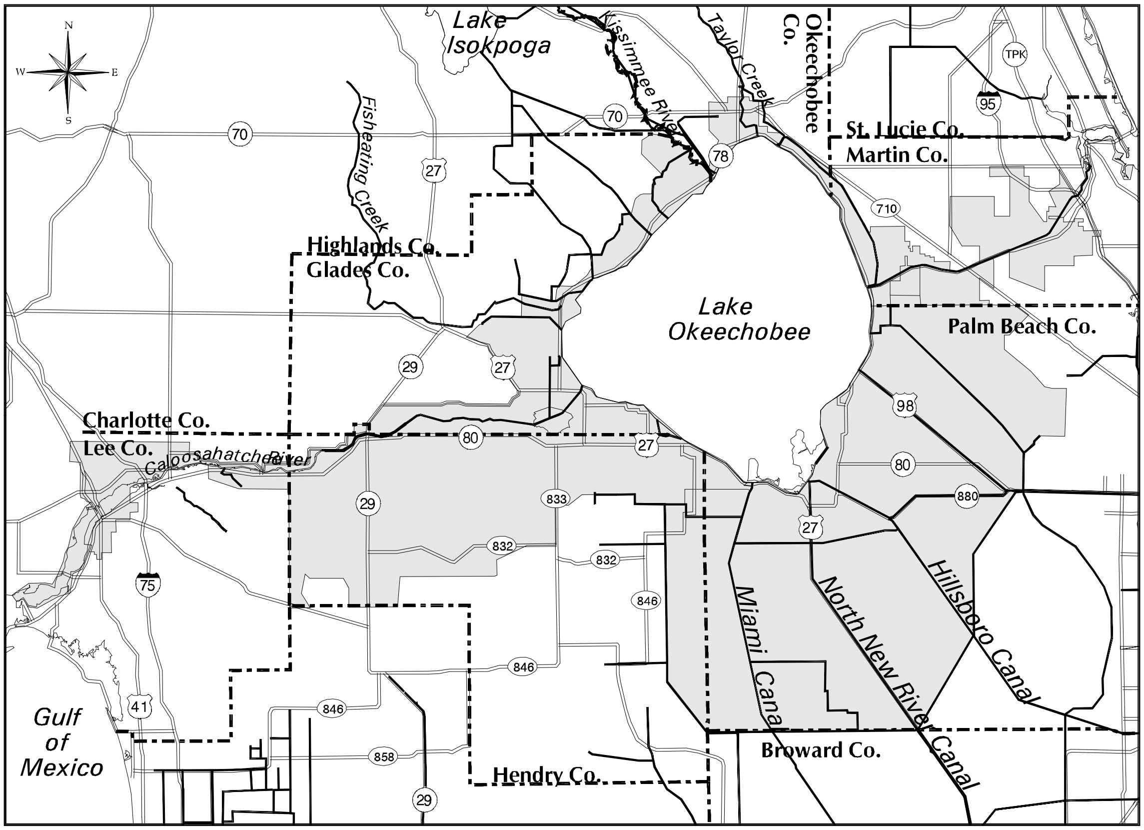

Figure 17. The Lake Okeechobee Service Area, including the Everglades Agricultural Area.

Flood control works on Lake Okeechobee consist of a system of about 1,000 miles of encircling levees, designed to withstand severe flood stage and wind conditions, plus the regulatory and water supply outlets of the St. Lucie Canal and the Caloosahatchee River. The design discharge of Moore Haven Spillway is 9,300 cubic foot per second (cfs) and that of St. Lucie Spillway is about 16,000 cfs. Following removal of local runoff from the agricultural areas south of the lake, an additional regulatory capability of several thousand cfs is available through the Miami, North New River, Hillsboro, and West Palm Beach canals by pumping into the WCAs

Everglades Protection Area

The Everglades Protection Area lies south of the EAA, west of the Atlantic Coastal Ridge, and east of the Big Cypress Preserve. It is comprised of a number of different management areas that have different operational needs and priorities, including the WCAs; the Holey Land and Rotenberger Wildlife Management Areas (WMAs); and Everglades National Park, which also includes Florida Bay.

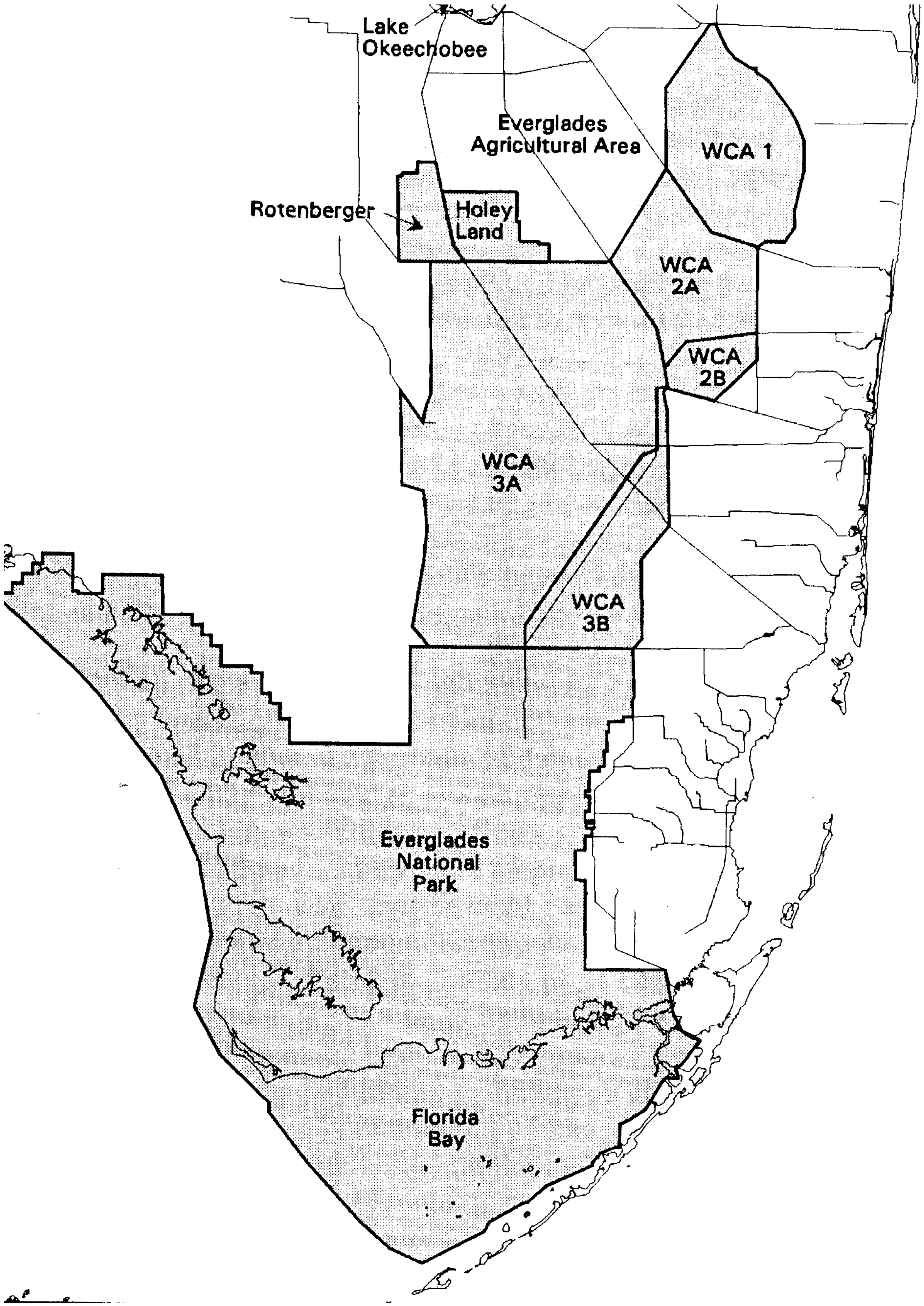

Figure 18. Everglades Protection Area.

The Everglades is an internationally recognized ecosystem that covers approximately two million acres in South Florida and represents the largest subtropical wetland in the United States. Prior to drainage and development, this area consisted largely of vast sawgrass plains, dotted with tree islands and interspersed with wet prairies and aquatic sloughs covering most of southeastern Florida (Davis, 1943). Everglades National Park and the WCAs are the surviving remnants of the historical Everglades, which extended over an area approximately 40 miles wide by 100 miles long, from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay. This remaining area provides significant ecological, water storage, flood control, and recreational benefits to the region, as well as important habitat for wildlife of national significance. The predrainage Everglades had three essential characteristics: 1) it was largely a rainfall-driven ecosystem, 2) it contained large spatial scale and extent, and 3) its hydrologic regime featured dynamic storage and sheetflow.

Construction of canals, levees, and water control structures as part of the C&SF Project has compartmentalized the WCAs into five separate reservoirs. These five WCAs contain the last remnants of the tall sawgrass, wet prairie, deep water slough, and tree island landscapes that remain intact outside of Everglades National Park. The primary purposes for the WCAs and their levees, canals, structures, and pump stations include flood control, water conservation, prevention of saltwater intrusion, recreation, preservation of fish and wildlife, and water supply for Everglades National Park. The WCAs are completely contained by levees, except for about seven miles on the west side of WCA-3A, which has a tieback levee. Additional levees on the east side of the east Everglades protect adjacent agricultural and industrial areas. This whole region is managed with a system of canals, pump stations, and control structures.

The WCAs provide a detention reservoir for excess water from the agricultural area and parts of the LEC Planning Area, and for flood discharges from Lake Okeechobee. The WCAs levees prevent Everglades floodwaters from inundating east coast urban areas and contain water that can be supplied to east coast areas and Everglades National Park. In addition, these levees help maintain higher water levels that provide recharge to surficial aquifers, ameliorate saltwater intrusion in coastal basins, reduce seepage, and benefit fish and wildlife in the Everglades.

The WCA regulation schedules essentially represent seasonal and monthly limits of storage. This seasonal range permits the storage of runoff during the wet season for use during the dry season. In addition, it maintains and preserves native plant communities, which are essential to fish and wildlife and the prevention of wind tides. The regulation schedules for water conservation include a minimum water level, below which water releases are not permitted unless water is supplied from another source. When water levels fall below the minimum levels, transfers from Lake Okeechobee or the WCAs are thus made to meet water demands.

East Coast Canals and Service Areas

Coastal Canals

The East Coast Canals are the flood control and outlet works that extend from St. Lucie County southward through Martin, Palm Beach, and Broward counties to Miami-Dade County, a distance along the coast of about 170 miles. The South Miami-Dade Conveyance System was added to the existing flood control system to provide a way to deliver water to areas of south Miami-Dade County.

The main design functions of project canals and structures in East Coast Canals are to protect adjacent lands against floods; store water in the WCAs; control water elevations; and provide water for conservation and human uses. These works protect against major flood damages. However, due to urbanization, the existing surface water management system now has to handle greater peak flows than in the past. Project works consist of 40 operating canals, one levee, and 50 operating structures. The operating structures consist of 35 spillways, 14 culverts, and one pump station. Many of these canals are used to remove water from interior areas to tidewater. Damages to agriculture, citrus, and pasturelands have been reduced due to the effective drainage capabilities of the canals. The project works maintain optimum stages for flood control, water supply, ground water recharge, and prevention of saltwater intrusion.

Areas become flooded during heavy rainfall events due to antecedent conditions that cause saturation and high runoff from both developed and undeveloped areas. To reduce the threat of flooding, automatic controls have been installed on some control structures. Saltwater intrusion has declined considerably at coastal structures since the installation of salinity dams downstream and salinity sensors near the structures.

The coastal canals and control structures are designed to permit rapid removal of floodwaters from their immediately adjacent drainage area. The degree of flood protection provided by outlet capacity depends on whether the protected area is urban or agricultural. Maximum rates of removal vary from 40-100 percent of the Standard Project Flood. Standard Project Flood is a mathematically derived severe storm event.

The network of canals and control structures also provide capacity for water supply and salinity control in the area. Wellfields, which are the primary source of municipal water supplies, are significantly recharged by releasing water from the WCAs and conveying this water through coastal canals to the vicinity of the wellfields. Water stored in the WCAs can also be used to maintain ground water levels and a freshwater head for salinity control in the coastal area and to irrigate agricultural areas.

Northern Palm Beach County Service Area

The North Palm Beach County Service Area (NPBCSA) includes all of the coastal and inland portions of Northern Palm Beach County west of the EAA and north of the West Palm Beach Canal Basin (C-51) (**Figure 19**). In presenting the results of the plan, the southern L-8 Basin and the M-Canal/Water Catchment Area Basins are included with the NPBCSA. This service area contains extensive urban, agricultural, and natural areas. The major natural areas within the NPBCSA include the DuPuis Reserve, the Corbett Wildlife Management Area, the West Palm Beach Water Catchment Area, the Loxahatchee Slough, the Loxahatchee River, and the Pal Mar Wetlands. The urban areas have experienced rapid growth for several decades and a continuation of this growth is expected through 2010. Agricultural land uses occur mostly in the L-8 and C-18 Basins. The major utilities in the NPBCSA include West Palm Beach, Riviera Beach, Seacoast, Jupiter, and Tequesta.

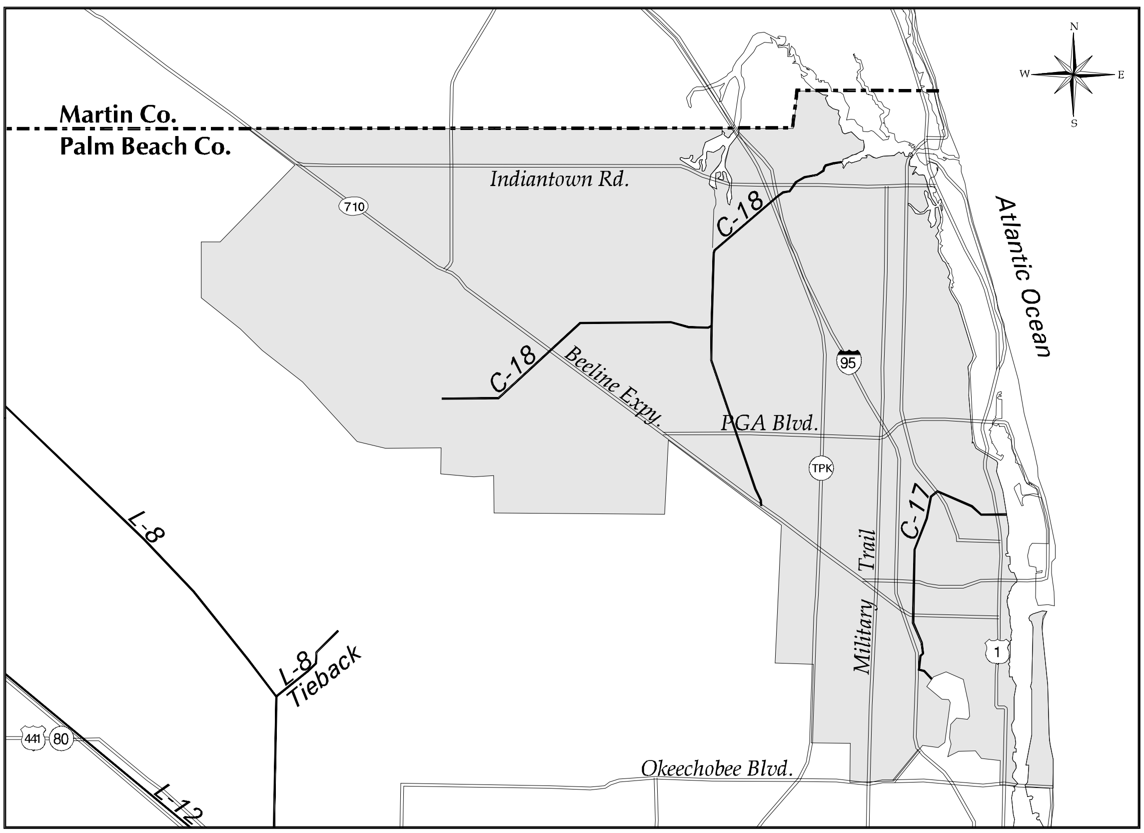

Figure 19. The North Palm Beach County Service Area, including the Everglades Agricultural Area.

Lower East Coast Service Area 1

The Lower East Coast Service Area 1 (LECSA 1) includes the portion of Palm Beach County east of WCA-1 and a small portion of Broward County (**Figure 20**). The service area includes the West Palm Beach Canal (C-51) and Hillsboro basins. This Service Area is heavily urbanized and has experienced rapid growth for several decades. A large amount of agriculture, principally winter vegetables, citrus and nurseries are located in the western portions of the service area. Utilities within Palm Beach County, which are in LECSA 1 include Lake Worth, Lantana, Delray Beach, Highland Beach, Boca Raton, Royal Palm Beach, Acme, Palm Beach County, Palm Springs, Atlantis, Jamaica Bay, Boynton Beach, Manalapan, and the Village of Golf. The utilities in Broward County which fall into LECSA 1 include a section of Broward County 2A, Deerfield Beach, the North Springs Improvement District, and Parkland.

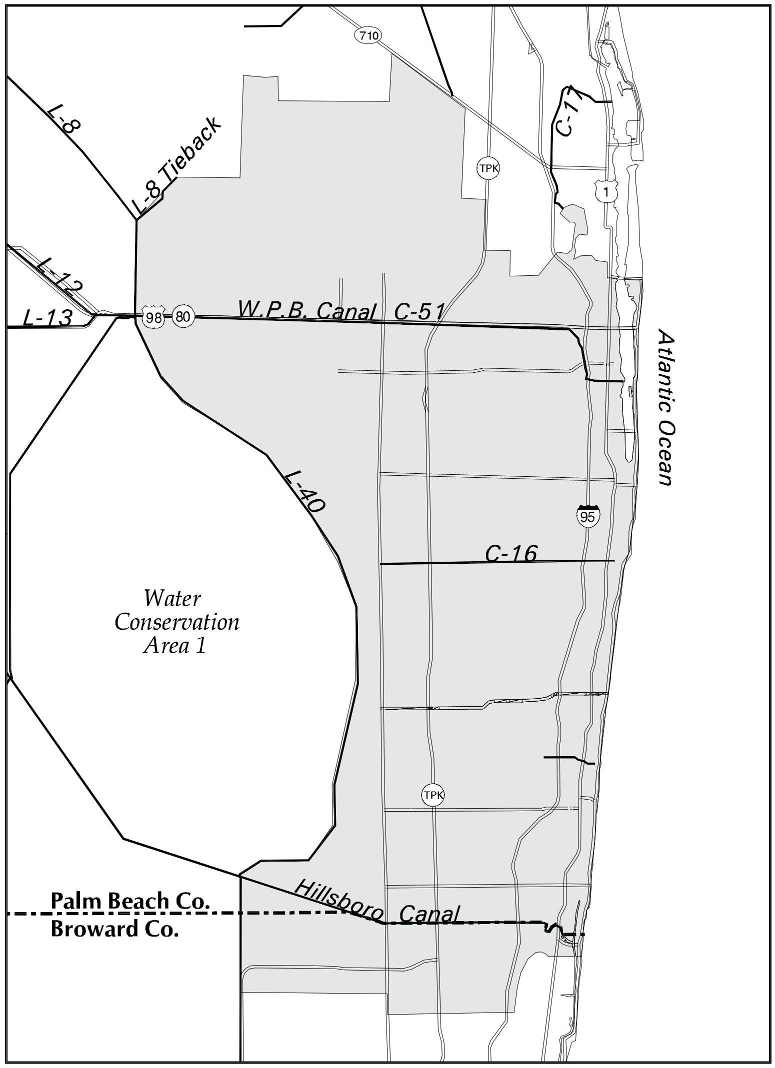

Figure 20. The Lower East Coast Service Area 1.

Lower East Coast Service Area 2

Lower East Coast Service Area 2 (LECSA 2) includes the portion of the Broward County east of the WCAs and south of the Hillsboro Canal Basin and the C-9 Canal Basin in northern Miami-Dade County (**Figure 21**). This LECSA 2 is heavily urbanized and has experienced rapid growth for several decades. While the rate of growth is slowing, the increasing population results in significant increases in demand for potable water.

Utilities within Broward County which are within Service Area 2 include Broadview; Broadview Park; Broward County 1A, 1B, 3A, and 3B; Cooper City; City of Coral Springs; Coral Springs Improvement District; Dania; Davie; Ferncrest; Fort Lauderdale; Hallandale; Hillsboro Beach; Hollywood; Lauderhill; Margate; Miramar; North Lauderdale; Pembroke Pines; Plantation; Pompano Beach; Royal; Seminole Industries; South Broward; Sunrise; and Tamarac. One utility within Miami-Dade County, North Miami Beach, lies within this area.

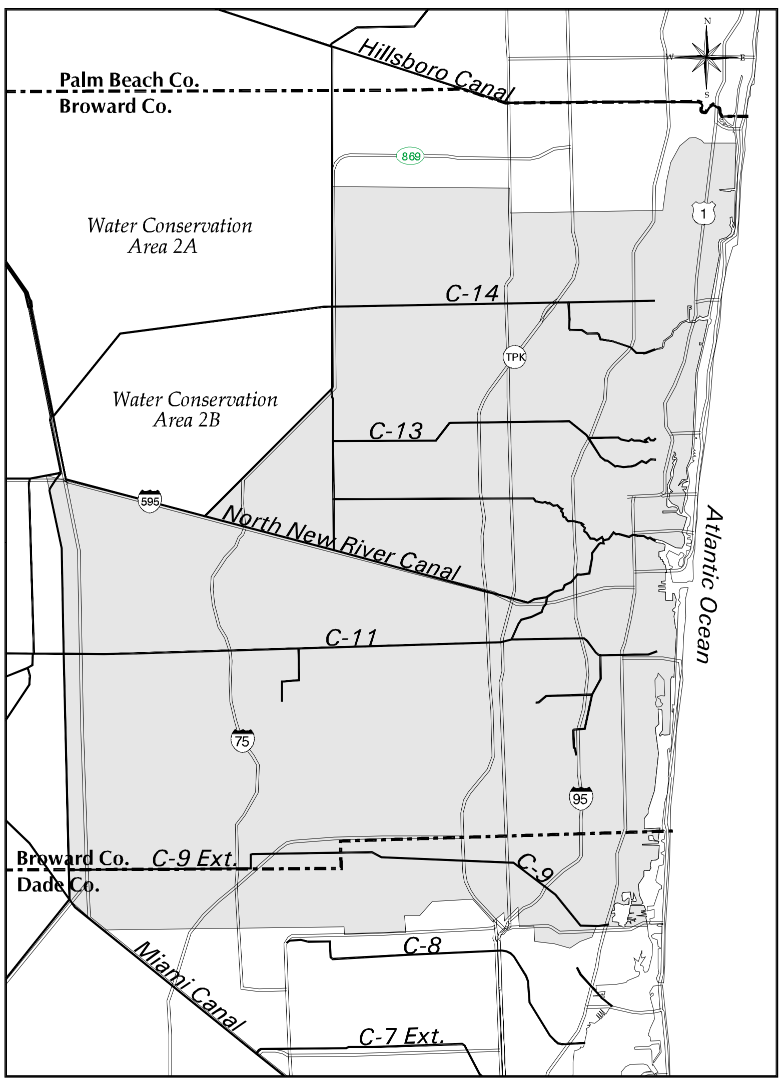

Figure 21. The Lower East Coast Service Area 2.

Lower East Coast Service Area 3

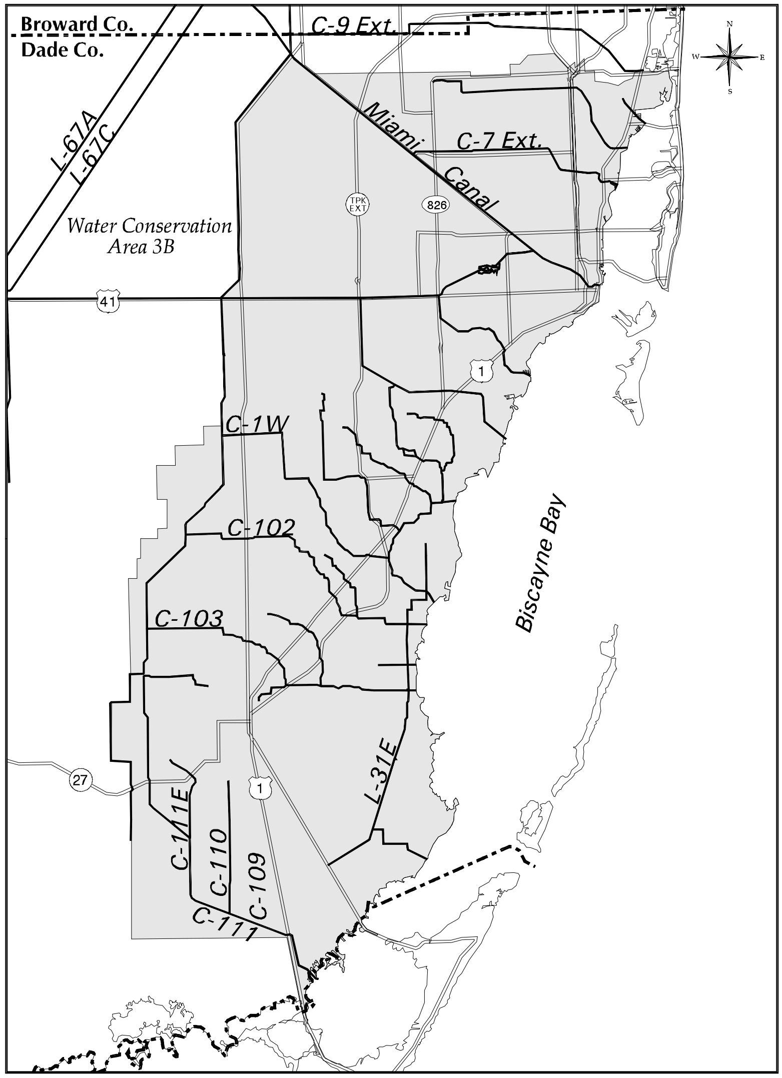

Figure 22. The Lower East Coast Service Area 3.

Lower East Coast Service Area 3 (LECSA 3) includes that portion of Miami-Dade County east of WCA-3B, and Everglades National Park, as well as the Florida Keys (**Figure 22**). The Florida Keys are included in LECSA 3 because their primary source of drinking water is the Florida Keys Aqueduct Authority wellfield located near Florida City.

Other major water suppliers in this service area include Miami-Dade Water and Sewer Authority Department, the City of North Miami, the City of Homestead, Florida City, and Homestead Air Force Base.

Water demand in LECSA 3 is generated primarily by a mixture of urban and agricultural land uses. Population is expected to grow through and displace some of the agriculture currently in southern Miami-Dade County. The citrus, winter vegetables, and tropical fruit farming in south Miami-Dade currently represents the second largest agricultural area in South Florida. Early efforts to drain the area caused significant saltwater intrusion and the abandonment of coastal wellfields in favor of large, regional wellfields located west of the Coastal ridge. The saltwater intrusion situation along the coast now appears to have stabilized.

During dry periods, rainfall and seepage are insufficient to maintain the Biscayne Aquifer at levels which meet demands and prevent saltwater intrusion. In these times the area is highly dependent on additional deliveries from regional storage via the C-4 and C-6 canals for the recharge of major Public Water Supply (PWS) wellfields.

Besides local rainfall, Service Area 3 receives large quantities of regional water due to ground water seeping from WCA-3B and Everglades National Park. Due to this seepage, efforts to restore water levels in areas west of the levee system impact the drainage needs of land uses adjacent to the levee system, while helping to recharge major PWS wellfields.

SOCIOECONOMICS

The economy of South Florida is based on services, agriculture, and tourism. Florida's warm weather and extensive coastline attract vacationers and other visitors and helps to make the state a significant retirement destination for people from all over the country. The 16 South Florida counties that fall within the SFWMD had a 1990 population of 6.3 million, accounting for nearly half (about 49 percent) of Florida's total. This share has changed very little over the past 20 years and recent U.S Department of Commerce projections predict it will remain stable over the next 50 years. Over 60 percent of this South Florida population lives in Palm Beach, Broward, and Miami-Dade counties. By 2020, the LEC Planning Area population may reach over 6.9 million.

About one-third of Florida’s employment and earnings occurs in the LEC Planning Area. Palm Beach, Broward, and Miami-Dade counties account for about 80 percent of the District’s regional aggregate socioeconomic activity. Employment and income within the District have continued to grow in recent decades faster than the national average. Growth has been significantly greater in the southwest counties of the planning area and the Florida Keys (Monroe, Collier, and Hendry) than elsewhere in the U.S. Department of Commerce’s study area.

LAND USE

Existing use of land within the study boundaries varies from undeveloped to high-density multifamily and industrial urban uses. Much of South Florida remains undeveloped, although much of this is disturbed land. The dominant natural features are Everglades National Park, Lake Okeechobee, and the WCAs. Generally, urban development is concentrated along the lower east coast from Palm Beach to Miami-Dade counties, with a number of small communities surrounding Lake Okeechobee. Agriculture plays an important role in the region. More than two million acres are being farmed, half of which is pasture land. Predominant crops are sugarcane and vegetables. Vegetable crops, especially tropical varieties, also dominate in southern Miami-Dade County. Citrus is grown in every county within the LEC Planning Area, but is concentrated in Collier County. The EAA has of over 700,000 acres of irrigated farmland producing sugarcane, rice, row crops, and sod. Extensive pasture lands are located west and north of Lake Okeechobee. Directly south of the EAA, the WCAs cover 1,372 square miles and consist mainly of sawgrass marshes and tree islands.

The urban area extends approximately 100 miles through the coastal portions of Palm Beach, Broward, and Miami-Dade counties and is the most densely populated subregion in the state with more than 4.5 million people. The subregion also contains substantial agricultural acreage, particularly in southwestern Miami-Dade County (90,000 acres) and eastern Palm Beach County (29,000 acres). Rapid population growth and land development practices have resulted in notable western urban sprawl, with the predominant land use being single-family residential.

The Florida Keys are made up of over 1,700 islands that encompass approximately 100 square miles and contain the largest reef system in the United States. While most of Monroe County is designated as conservation land within Everglades National Park, Big Cypress National Preserve, or the National Key Deer Refuge, use of most of the remaining land is either residential or geared towards supporting tourism, the region's main industry.

Collier County is the fastest growing, based on rate of population increase, in the LEC Planning Area. Population growth is mainly due to the influx of retirees. The coast has become highly urbanized, with development spreading eastward into agricultural and natural lands. However, agriculture is still a major industry.

RECREATION RESOURCES

Recreation opportunities abound in the LEC Planning Area. Central and South Florida are rich in water resources, with easy access to fresh, estuarine, and marine resources for fishing, boating, swimming, diving, camping, and sightseeing. Lake Okeechobee is a nationally recognized bass and pan fishing resource and offers other recreational amenities as well. Airboat and swamp buggy rides, hunting, bike riding, hiking, picnicking, camping, and nature interpretation are popular land based recreation activities.

The urbanized east coast includes good quality marine based recreation activities such as underwater diving, fishing, boating, surfing, and, of course, the beach. County and state parks, scenic rivers, state reserves and forests, and federal refuges provide wildlife viewing, nature interpretation, hiking, and canoeing opportunities. Arthur R. Marshall Loxahatchee National Wildlife Refuge (WCA-1), Scenic River, DuPuis Reserve State Forest, and the Loxahatchee River–Lake Worth Creek Aquatic Preserve provide high quality opportunities for boating, fishing, and nature interpretation activities. Biscayne Bay offers probably the highest quality recreation opportunities within the study area. Biscayne National Park provides opportunities for bird watching, recreational hiking, boating, fishing, snorkeling, diving, and picnicking.

The LEC Planning Area also has inland water and upland resources that include WCA-1 and the Rotenberger and Holey Land, wildlife management areas. These areas provide high quality boating, fishing, and nature interpretation activities. The Miccosukee State Indian Reservation offers opportunities for hunting, boating, and fishing. Fishing, hunting, boating, and air boating are popular activities in the WCAs and wildlife management areas.

Everglades National Park and Florida Bay offer unique and diverse recreational pursuits. Day use and camping facilities are available. Recreation opportunities include hiking trails, boating, fishing, and nature interpretation. Several roads open up access to diverse ecosystems within the Everglades National Park. Shark River Slough furnishes a lookout tower, tramway, biking, interpretive center, and camping. Florida Bay, Whitewater Bay, and the Ten Thousand Islands are characterized primarily by water-based resources and include excellent boating, fishing, and nature interpretation. Camping and other day use activities are also popular in the region.

The Florida Keys are very popular tourist destinations and offer high quality water-based recreation with some upland shoreline activities. Five wildlife refuges and one of the busiest state parks are located here. John Pennekamp Coral Reef State Park and the Florida Keys National Marine Sanctuary were created to protect for the delicate reefs that are also popular diving destinations. Diving, boating, fishing, and nature watching are the most popular recreation activities.

WATER SUPPLY AND FLOOD CONTROL

Management Considerations

One primary function of the C&SF Project is to provide a highly efficient flood control system, which is designed to keep urban and agricultural areas dry in the wet season. Flood protection is provided by discharging excess water to tide or into the WCAs and Everglades National Park. Rapid wet season flood releases to tide, coupled with the reduced capacity to retain water in Lake Okeechobee, the northern historical sawgrass plains, and the eastern peripheral wetlands and sloughs, have severely reduced the overall ability to store water in the regional system.

The sawgrass plains, for example, once stored and slowly released much of the water that overflowed from Lake Okeechobee. Today, large areas of these sawgrass plains have been converted to agriculture within the EAA. Water from the lake and excess runoff water are now quickly passed to the WCAs and the coast during the wet season to prevent crop damage. Water levels in coastal canals are maintained at relatively low levels during the wet season to provide additional capacity for storage and conveyance of flood waters, resulting in low ground water levels.

Another impact of the loss of water storage is that during the dry season high levels of demands may exceed the capacity to obtain water from nearby wetlands. When this occurs, water is released from Lake Okeechobee to meet crop and urban demands. Lack of storage, not a lack of water, is the problem. During dry periods, minimum levels for lower east coast canals are principally maintained to protect the Biscayne aquifer from saltwater intrusion. The head created in the canals raises ground water levels, recharging the aquifer and the urban wellfields, but also increases the likelihood that localized flooding will occur during an extreme storm event. During the wet season, wellfields are recharged by local rainfall and by seepage from the Everglades and the canals. During the dry season, recharge is more dependent on the regional system. Unfortunately, during both the wet and dry seasons, excess storm water is passed through the canals and out to tide when it should be stored. Without sufficient storage, it is difficult to have water available during dry periods and avoid flooding during wet periods.

While sufficient water is present to meet local needs during wet seasons and normal rainfall years, during extremely dry years, urban wellfields depend heavily on seepage and releases from WCAs and Lake Okeechobee. During drought years, urban and agricultural areas have additional needs and more water is used for landscape maintenance, primarily to water lawns.

The amount of water needed to recharge urban wellfields is less than to the volumes needed to prevent saltwater intrusion. However, the cost of replacing damaged wells is very high. The amount of water needed to prevent saltwater intrusion, in turn, is much less than the wet season coastal discharges. If coastal flows were captured and stored, more than enough water would be available to maintain dry season salinity barriers without removing water from the natural system.

Within the LEC Planning Area, ecological benefits may accrue from maintaining higher ground water levels. Low ground water levels have had serious negative effects on Biscayne Bay for example, including increased salinity, lower visibility, and lower water quality. In south Miami-Dade County, lowered ground water levels have caused wetland desiccation and shifts in vegetation from freshwater marshes that existed next to the bay in the early 1900s to saltmarsh and mangrove communities that predominate today.

Present Operation of the Regional System

Sources of Water Supply

Local water supply utilities and individual users obtain water from two primary sources: 1) by withdrawal from a surface water body such as a canal, lake, river, or wetland; or 2) by withdrawal from a ground water well. Virtually all of the LEC public water supply is from groundwater except for West Palm Beach. Throughout much of the LEC Planning Area, a regional system of canals and WCAs provides a means to move water from one location to another. Water is transported generally from north to south, from Lake Okeechobee through water control structures to the EAA canals and into the WCAs. Water flows from the WCAs via structures and canals to Everglades National Park and the coastal basins. Water in coastal canals provides recharge to surficial aquifers, thus enhancing ground water supplies and helping replenish water in lakes, rivers, and wetlands.

Management During Wet Periods

During wet years, seepage from the Everglades is generally more than adequate to maintain water levels in the coastal aquifers and no releases for this purpose are required. However, releases through coastal canals may be required to maintain regulation schedules in natural storage areas, such as Lake Okeechobee and the WCAs, and to provide flood protection.

In order to promote development of coastal basins for urban and agricultural use during the past century, water levels along the coastal ridge have been lowered by construction of drainage facilities. Over time, drainage has continued further westward to allow replacement of most of the wetlands in the Transverse Glades areas in Miami-Dade and Broward counties with homes, farms, and nurseries. Large areas have been dewatered and mined for the underlying rock that is used for roads and fill.

Due to the high transmissivity of the surficial (Biscayne) aquifer, lowering of water levels to protect one area results in reduction of water levels over large areas. Attempts to provide drainage and flood protection to coastal areas have thus lowered water tables and shortened hydroperiods of wetlands further west into the Everglades. Large amounts of fresh water that would have remained in these wetlands or moved slowly southward to Everglades National Park have been lost as surface water flow through coastal canals to Biscayne Bay.

Analyses conducted for the Restudy and for the development of the *LEC Regional Water Supply Plan* have attempted to compensate for the effects of drainage by establishing long-term restoration goals and management targets that reflect how the natural systems functioned before the area was drained. The Natural Systems Model (NSM) is used to represent predrainage conditions by simulating hydrologic conditions that existed before canals were constructed and before water levels and topography were altered by drainage. The water levels predicted by the NSM, in conjunction with historical data and expert opinion, were used for the Restudy as a basis to establish Everglades restoration goals for both low water and high water conditions. Consumptive use permits, in turn, consider the low water restoration water levels as the "no harm standard" that should be maintained under all conditions less severe than a 1-in-10 year drought.

Due to the conceptual nature of the Restudy and the modeling tools used for the alternative analyses, detailed flood damage assessment was not performed for the Restudy. However, maintaining levels of flood protection remains an important purpose of the C&SF Project and an objective of the CERP. The USACE will carefully evaluate any potential flood control impacts before any Restudy/CERP components are built. Project Implementation Reports for individual components or groups of components will include a detailed review of flood protection for the area affected by the components. Opportunities for enhancing flood protection in conjunction with other design objectives will be investigated. In addition, the Restudy report includes the statement "Flood level protection monitoring will ensure that the existing level of protection is not compromised as a result of implementation of the recommended plan ." (USACE, 1999).

Management During Droughts

During dry years, additional water may be released from the regional system through the coastal canals to help recharge surficial aquifers in the coastal basins. These water supply releases are made on an as needed basis, triggered either by a decline in water levels in the canals below their maintenance levels or a movement of the saltwater front in the coastal aquifers as detected in monitoring or production wells. **Figures 23** and **24** show how regional water conveyance facilities are managed during wet and dry periods.

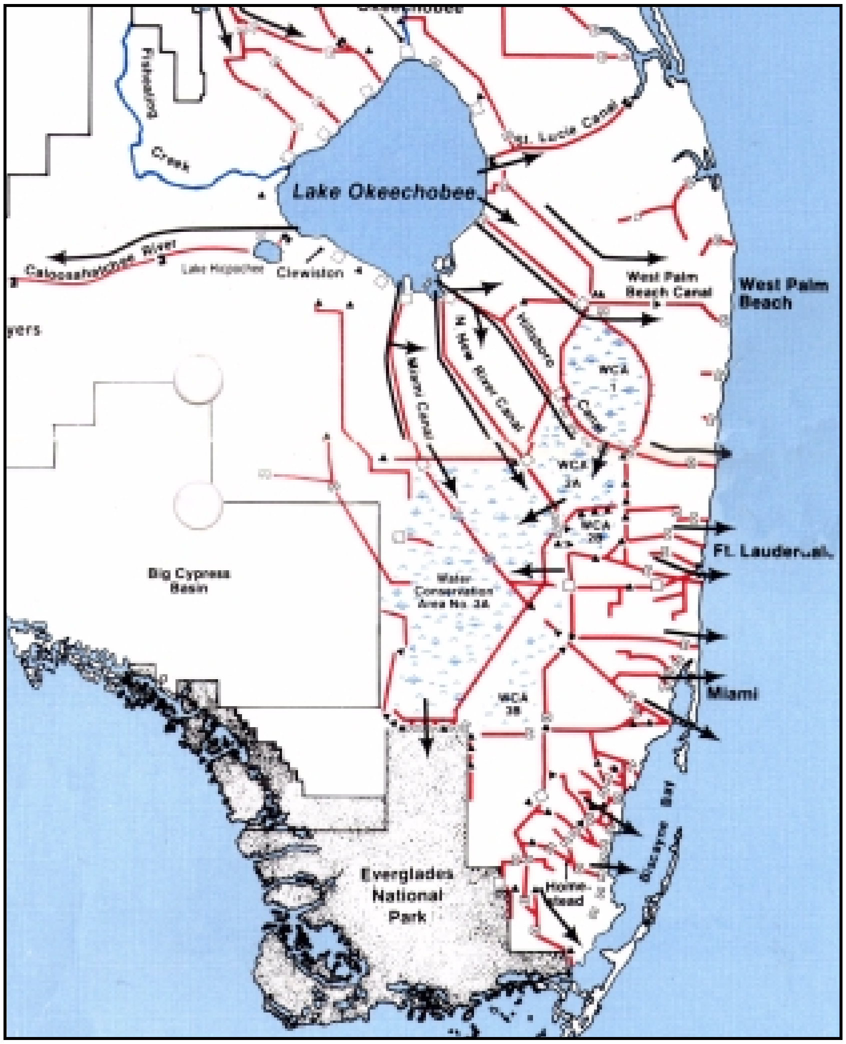

Figure 23. Water Conveyance in the Regional Systems During Wet Periods. Arrows Indicate Direction of Pumpage or Flow.

Supply-Side Management

Water supply allocations from lake Okeechobee during a drought are determined based on a Supply-Side Management Plan. According to this plan, the amount of water available for use during any period of time is a function of the anticipated rainfall, lake evaporation, and water demands for the balance of the dry season in relation to the amount of water currently in storage. Water availability in Lake Okeechobee is calculated on a weekly basis, along with a provision that allows users to borrow from their future supply to supplement existing shortfalls. The borrowing provision places the decision of risk with the user and can significantly affect the distribution of benefits among users because the amount of water borrowed is mathematically subtracted from future allocations. The

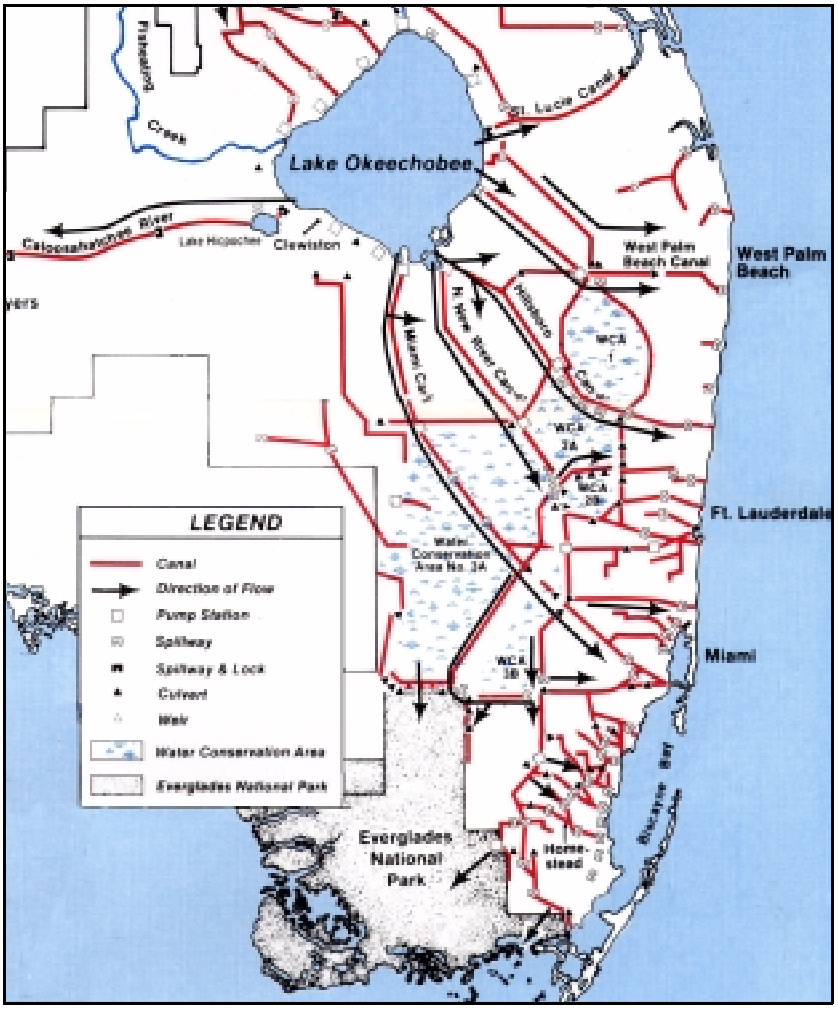

Figure 24. Water Conveyance in the Regional Systems During Dry Periods. Arrows Indicate Direction of Pumpage or Flow.

Supply-Side Management Plan is implemented if it is projected that the lake could fall below 11 ft NGVD at the end of the dry season (May 31).

For Lake Okeechobee, the current procedure lies in the calculation of water demands. At the present time, this value is limited to estimation of irrigation demands in four agricultural basins: the North Shore, the Caloosahatchee, the St. Lucie, and the EAA. Lower East Coast urban demands were omitted because they are not generally required during a normal rainfall year; however, they can be significant during dry periods. Another major omission from this calculation is the environmental demand. As part of the LEC Regional Water Supply Plan, steps will be recommended to improve supply-side management and water shortage management.

Water Shortage Frequencies

The frequency of water shortages is defined based on statistical analysis of data from a particular monitoring station, basin, or region. The numbers represent the estimated time period between occurrences of events that have similar magnitude. Drought events can be defined for different time periods (monthly, dry season, wet season, annual, and biannual) based on a number of different criteria, including lack of sufficient rainfall, lack of adequate water levels in the aquifer, or lack of water available in the regional system.

For example, assume that the average rainfall is 54 inches per year in a particular basin and rainfall of 47 inches occurs this year. Based on statistical analysis of historical data from rainfall monitoring stations within this basin, this degree of deficiency was determined to occur once every ten years. Annual rainfall of 47 inches thus corresponds to a 1-in-10 year drought condition for that basin based on rainfall. Different water management actions may be required, depending on the location, nature, and magnitude of the drought.